CLAIMS

What is claimed is:

1. A method of designing a geothermal heat exchange system comprising:

providing a refrigerant liquid line and a refrigerant vapor line;

providing a refrigerant heat exchange line having a first end portion connected to the refrigerant liquid line and a second end portion connected to the refrigerant vapor line;

providing a liquid container containing a heat conductive liquid up to a liquid level, the refrigerant heat exchange line positioned within the container below the liquid level and in thermal contact with the heat conductive liquid;

wherein the refrigerant liquid line, the refrigerant vapor line, and the refrigerant heat exchange line adapted to circulate refrigerant into and out of the liquid container;

providing a liquid casement having a top portion, a bottom portion, and an inner diameter, at least the bottom portion of the casement in thermal contact with sub-surface material proximate the casement;

providing a liquid supply pipe extending from the bottom portion of the casement, out of the casement, and into the liquid container, the liquid supply pipe having an outer diameter that is smaller than the inner diameter of the casement;

providing a liquid return pipe extending from the liquid container to the top portion of the casement; and

providing a liquid pump operatively connected to the liquid supply pipe and to the liquid return pipe, the liquid pump, the liquid supply pipe, and the liquid return pipe operative to circulate the heat conductive liquid from the bottom portion of the casement, into the liquid container, around the refrigerant heat exchange line, out of the liquid container, and to the top portion of the casement.

2. The method of claim 1, further comprising providing a system wherein:

the system is operative in a cooling mode;

the liquid return pipe is positioned within the container so that when the system is operating in the cooling mode, the liquid return pipe receives the heat conductive liquid proximate the second end portion of the refrigerant heat exchange line; and

the liquid supply pipe is positioned within the container so that when the system is operating in the cooling mode, the liquid supply pipe discharges the heat conductive liquid proximate the first end portion of the refrigerant heat exchange line.

3. The method of either of claim 1 or claim 2, further comprising providing a system wherein:

the system is operative in a heating mode; the liquid return pipe is positioned within the container so that when the system is operating in the heating mode, the liquid return pipe receives the heat conductive liquid proximate the first end portion of the refrigerant heat exchange line; and

the liquid supply pipe is positioned within the container so that when the system is operating in the heating mode, the liquid supply pipe discharges the heat conductive liquid proximate the second end portion of the refrigerant exchange line.

4. The method of claim 3 further comprising providing valve means connected to the liquid return and supply pipes, the valve means operative to reverse direction of circulation of the heat conductive liquid into and out of the liquid container when the system is switched between the cooling and heating modes.

5. The method of claim 1 further comprising providing a solar liquid heating system connected to the liquid container and operative to supply heat to the heat conductive liquid in the container when the heat supplied by the solar liquid heating system has a temperature that exceeds the temperature of the heat conductive liquid in the container.

6. The method of claim 5 further comprising providing a system wherein the solar liquid heating system comprises:

a solar heat collector, solar heat refrigerant, a solar heat refrigerant supply line and a solar heat refrigerant return line;

solar heat sink lines positioned in the liquid container below the liquid level and in thermal contact with the heat conductive liquid; and

the solar heat refrigerant supply and return lines connecting the solar heat collector to the solar heat sink lines in the liquid container and operative to provide

circulation of the solar heat refrigerant between the solar heat collector and through the solar heat sink lines in the liquid container.

7. The method of claim 6 further comprising providing a system wherein the solar heat collector is positioned to be below the liquid level in the container so that the circulation of the solar heat refrigerant occurs as a consequence of evaporation of the solar heat refrigerant within the solar collector and solar heat refrigerant supply line and condensation of the solar heat refrigerant in the solar heat sink lines and the solar heat return line.

8. The method of claim 6 further comprising providing a system wherein the position of the solar heat sink lines within the container can be adjusted to modify the amount of solar heat directly supplied to the refrigerant heat exchange line.

9. The method of claim 1 further comprising:

providing a compressor operatively connected to the refrigerant vapor line; and

providing an interior heat exchange means operatively connected to the refrigerant liquid line and to the compressor.

10. The method of claim 9 further comprising providing a means to supply condensate water generated by operation of the interior heat exchange means so as to be in thermal contact with the refrigerant vapor line to promote evaporative cooling of the refrigerant vapor line.

11. The method of claim 1 further comprising providing thermal insulation applied to the liquid supply pipe, to the liquid return pipe, and to the liquid container.

12. The method of claim 1 further comprising providing a first liquid diffuser attached to the liquid supply pipe in the liquid container and a second liquid diffuser attached to the liquid return pipe in the liquid container.

13. A method of providing heat exchange in a direct expansion geothermal heating and cooling system comprising:

a. positioning a sealed casement such that at least a portion of the casement is in thermal contact with sub-surface material;

b. circulating a refrigerant through a heat transfer line in a liquid container; and

c. circulating a heat conductive liquid between the sealed casement and the liquid container so that the heat conductive liquid is placed in thermal contact with the heat transfer line and with the casement.

14. The method of claim 13 further comprising reversing circulation of the heat conductive liquid between the casement and the liquid container when the heating and cooling system is switched between a heating mode and a cooling mode.

15. The method of claim 14 further comprising circulating solar heated liquid through a solar heat sink in the container when the system is operated in the heating mode.

16. The method of claim 14 further comprising circulating the refrigerant through a compressor and an interior heat exchanger using refrigerant vapor and liquid lines, and applying condensate water produced by the interior heat exchanger to the refrigerant vapor line.

17. A method of designing a supplemental solar heating system for a direct expansion geothermal heat exchange system operating in the heating mode, comprising providing a supplemental solar heating system wherein heat acquired from a solar heat collector is conveyed by means of a fluid within transport tubing, and the solar heat is transferred, by a solar heat to direct expansion system refrigerant fluid heat exchange means, to the refrigerant fluid in a direct expansion system.

18. A method of designing a supplemental solar heating system for a direct expansion geothermal heat exchange system operating in the heating mode, comprising providing a supplemental solar heating system wherein heat acquired from a solar heat collector is conveyed by means of a fluid within transport tubing, and the solar heat is transferred, by a solar heat to direct expansion system refrigerant fluid heat exchange means, to the refrigerant fluid in a direct expansion system immediately prior to the refrigerant fluid entering the sub-surface geothermal heat transfer environment of the direct expansion system.

19. The method of claim 17 and 18, further comprising providing insulation, wherein all solar heat fluid transport tubes between the solar heat collector and the solar heat to refrigerant fluid heat exchange means are insulated, and where the exterior of the solar heat to refrigerant fluid heat exchange means is insulated.

20. The method of claim 17 and 18, further comprising providing a solar heat to refrigerant fluid heat exchange means, wherein the solar heat to refrigerant fluid heat exchange means is located at an elevation above that of the solar heat collector.

21. The method of claim 17 and 18, further comprising providing a solar heat transfer termination means, which solar heat transfer termination means is only activated when the direct expansion system is operating in the cooling mode, and during periods of time when the supplemental heat supplied by the solar heat collector is at a lower temperature than the maximum temperature in the geothermal heat exchange sub-surface environment, and which solar heat transfer termination means is otherwise de-activated.

22. The method of claim 17 and 18, further comprising providing a slope in the solar heat collector's heat transfer tubing, wherein the solar collector's heat transfer tubing is always sloped in an upward vertical orientation from the bottom of the solar heat collector to the top of the solar heat to direct expansion refrigerant fluid heat exchange means, and wherein the solar collector's heat transfer tubing is

always sloped in a downward vertical orientation from the top of the solar heat to direct expansion refrigerant fluid heat exchange means to the bottom of the solar heat collector.

23. The method of claim 17 and 18, further comprising providing an inverted U bend in the direct expansion heating system's refrigerant transport tubing situated above the solar heat to direct expansion refrigerant fluid heat exchange means.

24. The method of claim 17 and 18, further comprising providing locating the solar heat to direct expansion refrigerant fluid heat exchange means at a point in the direct expansion system's liquid refrigerant transport line after the direct expansion system's heating mode refrigerant expansion device and before the point where the direct expansion system's thermally exposed sub-surface refrigerant transport geothermal heat exchange tubing is located.

25. A method of designing a supplemental solar heating system comprising providing a closed-loop water-source geothermal heat pump system, operating in the heating mode, with a supplemental solar heating system wherein heat acquired from a solar heat collector is conveyed by means of a fluid within transport tubing, and wherein the solar heat is transferred to the one of water and water and antifreeze fluid circulating within the closed-loop water-source geothermal heat pump system by means of one of a solar heat to a water-source system

water/antifreeze fluid heat exchange means, and a solar heat to water-source system refrigerant fluid heat exchange means to a water-source system refrigerant fluid to water-source system water/antifreeze fluid heat exchange means.

26. A method of designing a supplemental solar heating system comprising providing a closed-loop water-source geothermal water-source heat pump system, operating in the heating mode, with a supplemental solar heating system wherein heat acquired from a solar heat collector is conveyed by means of a fluid within transport tubing, and wherein the solar heat is transferred to the one of water and water and antifreeze fluid circulating within the closed-loop water-source geothermal heat pump system by means of one of a solar heat to a water-source system water/antifreeze fluid heat exchange means, and a solar heat to water-source system refrigerant fluid heat exchange means to a water-source system refrigerant fluid to water-source system water/antifreeze fluid heat exchange means immediately before the water-source system's circulating water/antifreeze fluid enters the sub-surface geothermal heat transfer environment of the water-source system

27. The method of claim 25 and 26, further comprising providing insulation, wherein all solar heat fluid transport tubes between the solar heat collector and the one of solar heat to water/antifreeze fluid heat exchange means, and solar heat to refrigerant fluid heat exchange means to a refrigerant fluid to water/antifreeze fluid

heat exchange means, are insulated, and where the exteriors of the one of solar heat to water/antifreeze fluid heat exchange means, and solar heat to refrigerant fluid heat exchange means to a refrigerant fluid to water/antifreeze fluid heat exchange means, are insulated.

28. The method of claim 25 and 26, further comprising providing one of a solar heat to water/antifreeze fluid heat exchange means, and a solar heat to refrigerant fluid heat exchange means and a refrigerant fluid to water/antifreeze fluid heat exchange means, and wherein the one of solar heat to water/antifreeze fluid heat exchange means, and solar heat to refrigerant fluid heat exchange means, is located at an elevation above that of the solar heat collector.

29. The method of claim 25 and 26, further comprising providing a solar heat transfer termination means, which solar heat transfer termination means is only activated when the water-source heat pump heating and cooling system is operating in the cooling mode, and during periods of time in the heating mode when the supplemental heat supplied by the solar heat collector is at a lower temperature than the maximum temperature in the geothermal heat exchange sub-surface environment, and which solar heat transfer termination means is otherwise de-activated.

30. The method of claim 25 and 26, further comprising providing an inverted U bend in the water-source heat pump's heating system's one of water/antifreeze

fluid transport tubing, and refrigerant fluid transport tubing, which tubing containing the inverted U bend is situated above the one of solar heat to water/antifreeze fluid heat exchange means, and solar heat to refrigerant fluid heat exchange means.

31. The method of claim 25 and 26, further comprising providing a slope in the solar heat collector's heat transfer tubing, wherein the solar collector's heat transfer tubing is always sloped in an upward orientation from the bottom of the solar heat collector to the top of the one of the solar heat to water/antifreeze fluid heat exchange means, and solar heat to refrigerant fluid heat exchange means, and wherein the solar collector's heat transfer tubing is always sloped in a downward orientation from the top of the one of the solar heat to water/antifreeze fluid heat exchange means, and solar heat to refrigerant fluid heat exchange means, to the bottom of the solar heat collector.

32. A method of designing a direct expansion geothermal heat pump supplemental refrigerant vapor line cooling means comprising:

providing a compressor operatively connected to the refrigerant vapor line; and

providing an interior heat exchange means operatively connected to the refrigerant liquid line and to the compressor.

33. The method of claim 32 further comprising providing a means to supply condensate water generated by operation of the interior heat exchange means so as

to be in thermal contact with one of the refrigerant vapor line and an expanded surface area refrigerant vapor line segment to promote evaporative cooling of the refrigerant vapor line.

34. The method of claim 32 further comprising providing a means to supply water from any source so as to be in thermal contact with one of the refrigerant vapor line and an expanded surface area refrigerant vapor line segment to promote evaporative cooling of the refrigerant vapor line.

35. A method of designing a water-source geothermal heat pump supplemental refrigerant vapor line cooling means comprising:

providing a compressor operatively connected to the refrigerant vapor line; and

providing an interior heat exchange means operatively connected to the refrigerant liquid line and to the compressor.

36. The method of claim 35 further comprising providing a means to supply condensate water generated by operation of the interior heat exchange means so as to be in thermal contact with one of the refrigerant vapor line and an expanded surface area refrigerant vapor line segment to promote evaporative cooling of the refrigerant vapor line.

37. The method of claim 35 further comprising providing a means to supply water from any source so as to be in thermal contact with one of the refrigerant

vapor line and an expanded surface area refrigerant vapor line segment to promote evaporative cooling of the refrigerant vapor line.

38. A direct expansion geothermal heat exchange system, operating in the heating mode, comprising a supplemental solar heating system wherein heat acquired from a solar heat collector is conveyed by means of a fluid within transport tubing, and the solar heat is transferred, by a solar heat to direct expansion system refrigerant fluid heat exchange means, to the refrigerant fluid in a direct expansion system.

39. A geothermal direct expansion heat exchange system, operating in the heating mode, comprising a supplemental solar heating system wherein heat acquired from a solar heat collector is conveyed by means of a fluid within transport tubing, and the solar heat is transferred, by a solar heat to direct expansion system refrigerant fluid heat exchange means, to the refrigerant fluid immediately prior to the refrigerant fluid entering the sub-surface geothermal heat transfer environment of the direct expansion system.

40. The system of claim 38 and 39 wherein all solar heat fluid transport tubes between the solar heat collector and the solar heat to refrigerant fluid heat exchange means are insulated, and where the exterior of the solar heat to refrigerant fluid heat exchange means is insulated.

41. The system of claim 38 and 39 wherein the solar heat to refrigerant fluid heat exchange means is located at an elevation above that of the solar heat collector.

42. The system of claim 38 and 39 wherein a solar heat transfer termination means is provided, which solar heat transfer termination means is only activated when the direct expansion system is operating in the cooling mode, and during periods of time when the supplemental heat supplied by the solar heat collector is at a lower temperature than the maximum temperature in the geothermal heat exchange sub-surface environment, and which solar heat transfer termination means is otherwise de-activated.

43. The system of claim 38 and 39 wherein the solar collector's heat transfer tubing is always sloped in an upward vertical orientation from the bottom of the solar heat collector to the top of the solar heat to direct expansion refrigerant fluid heat exchange means, and wherein the solar collector's heat transfer tubing is always sloped in a downward vertical orientation from the top of the solar heat to direct expansion refrigerant fluid heat exchange means to the bottom of the solar heat collector.

44. The system of claim 38 and 39 wherein there is an inverted U bend in the direct expansion heating system's refrigerant transport tubing situated above the solar heat to direct expansion refrigerant fluid heat exchange means.

45. The system of claim 38 and 39 wherein the solar heat to direct expansion refrigerant fluid heat exchange means is situated at a point in the direct expansion system's liquid refrigerant transport line after the direct expansion system's heating mode refrigerant expansion device and before the point where the direct expansion system's thermally exposed sub-surface refrigerant transport geothermal heat exchange tubing is located.

46. A closed-loop water-source geothermal heat pump system, operating in the heating mode, comprising a supplemental solar heating system wherein heat acquired from a solar heat collector is conveyed by means of a fluid within transport tubing, and wherein the solar heat is transferred to the one of water and water and antifreeze fluid circulating within the closed-loop water-source geothermal heat pump system by means of one of a solar heat to a water-source system water/antifreeze fluid heat exchange means, and a solar heat to water-source system refrigerant fluid heat exchange means to a water-source system refrigerant fluid to water-source system water/antifreeze fluid heat exchange means.

47. A closed-loop water-source geothermal heat pump system, operating in the heating mode, comprising a supplemental solar heating system wherein heat acquired from a solar heat collector is conveyed by means of a fluid within transport tubing, and wherein the solar heat is transferred to the one of water and water and antifreeze fluid circulating within the closed-loop water-source geothermal heat

pump system by means of one of a solar heat to a water-source system water/antifreeze fluid heat exchange means, and a solar heat to water-source system refrigerant fluid heat exchange means to a water-source system refrigerant fluid to water-source system water/antifreeze fluid heat exchange means immediately before the water-source system's circulating water/antifreeze fluid enters the sub-surface geothermal heat transfer environment of the water-source system.

48. The system of claim 46 and 47 wherein all solar heat fluid transport tubes between the solar heat collector and the one of solar heat to water/antifreeze fluid heat exchange means, and solar heat to refrigerant fluid heat exchange means to a refrigerant fluid to water/antifreeze fluid heat exchange means, are insulated, and where the exteriors of the one of solar heat to water/antifreeze fluid heat exchange means, and solar heat to refrigerant fluid heat exchange means to a refrigerant fluid to water/antifreeze fluid heat exchange means, are insulated.

49. The system of claim 46 and 47 wherein the one of a solar heat to water/antifreeze fluid heat exchange means, and solar heat to refrigerant fluid heat exchange means and a refrigerant fluid to water/antifreeze fluid heat exchange means is provided, and wherein the one of solar heat to water/antifreeze fluid heat exchange means, and solar heat to refrigerant fluid heat exchange means, is located at an elevation above that of the solar heat collector.

50. The system of claim 46 and 47, wherein a solar heat transfer termination means is provided, which solar heat transfer termination means is only activated when the water-source heat pump heating and cooling system is operating in the cooling mode, and during periods of time in the heating mode when the supplemental heat supplied by the solar heat collector is at a lower temperature than the maximum temperature in the geothermal heat exchange sub-surface environment, and which solar heat transfer termination means is otherwise de-activated.

51. The system of claim 46 and 47 wherein there is an inverted U bend in the water-source heat pump's heating system's one of water/antifreeze fluid transport tubing, and refrigerant fluid transport tubing, which tubing containing the inverted U bend is situated above the one of solar heat to water/antifreeze fluid heat exchange means, and solar heat to refrigerant fluid heat exchange means.

52. The system of claim 46 and 47 wherein the solar collector's heat transfer tubing is always sloped in an upward orientation from the bottom of the solar heat collector to the top of the one of the solar heat to water/antifreeze fluid heat exchange means, and solar heat to refrigerant fluid heat exchange means, and wherein the solar collector's heat transfer tubing is always sloped in a downward orientation from the top of the one of the solar heat to water/antifreeze fluid heat

exchange means, and solar heat to refrigerant fluid heat exchange means, to the bottom of the solar heat collector.

53. A direct expansion geothermal heat pump system supplemental refrigerant vapor line cooling means comprising:

a compressor operatively connected to the refrigerant vapor line; and

an interior heat exchange means operatively connected to the refrigerant liquid line and to the compressor.

54. The system of claim 53 wherein condensate water generated by operation of the interior heat exchange means is supplied in a manner so as to be in thermal contact with one of the refrigerant vapor line and an expanded surface area refrigerant vapor line segment to promote evaporative cooling of the refrigerant vapor line.

55. The system of claim 53 wherein water from any source is supplied in a manner so as to be in thermal contact with one of the refrigerant vapor line and an expanded surface area refrigerant vapor line segment to promote evaporative cooling of the refrigerant vapor line.

56. A closed-loop water-source geothermal heat pump system supplemental refrigerant vapor line cooling means comprising:

a compressor operatively connected to the refrigerant vapor line; and

an interior heat exchange means operatively connected to the refrigerant liquid line and to the compressor.

57. The system of claim 56 wherein condensate water generated by operation of the interior heat exchange means is supplied in a manner so as to be in thermal contact with one of the refrigerant vapor line and an expanded surface area refrigerant vapor line segment to promote evaporative cooling of the refrigerant vapor line.

58. The system of claim 56 wherein water from any source is supplied in a manner so as to be in thermal contact with one of the refrigerant vapor line and an expanded surface area refrigerant vapor line segment to promote evaporative cooling of the refrigerant vapor line.